FOREST HEALTH PROTECTION
Pacific Southwest Region

FHP Report No. SS09 - 14

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To: Ken Romberger, Resource Management, PAL, Groveland Ranger District, Stanislaus NF

Subject: **Tree mortality in parts of the Middle Fork project area of the Stanislaus N. F.**

Background.

- When the Groveland Ranger District staff was marking stands in the Middle Fork Project Area they observed that they had marked as Hazard Trees, close to the roads, a disproportionate number of dead Douglas fir stems and began to suspect a Douglas fir disease was at work. Subsequently the South Sierra Shared Service Area pathologist and entomologist were asked to evaluate the situation.

- Unbeknown to the District staff the FHP staff had, the year before, observed roadside Douglas fir mortality along the edges of Highway 120 and had initiated a small scale investigation into the mortality.

- The initial response to the Ranger District was that they were observing Black Stain Root Disease (BSRD). While aerially sketchmapping the Stanislaus NF the flight path was deviated to fly over the parts of the project to obtain photographs of the area. A single photograph (image 1) made it abundantly clear that the mortality did not follow the clumped pattern that would be expected from a root disease.

- After the realization that the stand mortality level, when viewed from the air, was significantly higher that which had been observed from the ground (roadside) it was decided to conduct a tree health survey and use the data to formulate an explanation for the observed mortality. This report combines the information that was already known with the survey data and, attempts to provide a hypothesis to explain the observed mortality.

Healthy Forests Make A World Of Difference

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Image 1. The image that led to the tree health survey An aerial image captured on the 2008 FHP aerial flight over the Stanislaus National Forest. Notice that there are no large standing dead trees along the tree edge of the road. The GPS'ed flight path of the spotting aircraft gave the general location of this image and Ranger District staff found 3 points of confirmation. Once the image had been tentatively located the crowns of, and shadows cast by individual trees could be located on the ground.

Obsevations that had been made prior to the survey.

Previously, retired pathologist John Pronos had remarked that the stands of the Middle Fork Project contained the most southerly known location of Black Stain Root Disease (BSRD) in the native range of Douglas fir. BSRD is caused by the fungus *Leptographium wageneri* variety *pseudotsugae.* (Jacobs and Wingfield, 2001). While the southern limit of Douglas fir is on the High Sierra RD of the Sierra National Forest, BSRD is not known from that location. The Stanislaus Douglas fir site is at an elevation of just under 4,000 ft and the Sierra National Forest site is at over 5,000 ft. Initial investigations in the marked (for thinning) stands along Forest Road 1S68 confirmed the likelihood that the situation was BSRD mortality of Douglas fir. The observed stand had been thinned some year earlier and long dead, recently dead and dying Douglas fir trees were observed at the edges of what had been an old landing site from what had

been presumed to have been be a previous thinning (image 2). BSRD is well documented known as being associated with roads, skid trails and areas of tractor logging (Hessburg *et al* 1995).

Image 2. A site initially thought to represent a BSRD pocket. The old landing (fore ground) has been colonized by the disease resistant *P. ponderosa* and Douglas firs along the perimeter of the landing have been dying for many years. *Leptographium* was recovered from a small Douglas fir on the margin of this pocket

Although numerous, roadside Douglas fir saplings and poles along either forest road 1S68 or those stretches of Highway 120 (image 3) that pass though the middle fork project area were observed to exhibit the symptoms of BSRD, the majority of mature, dead or declining, trees did not exhibit the classical symptoms of BSRD. Diagnostic symptoms of BSRD (Hessburg *et al* 1995), include basal resinous associated with arcs of chocolate brown to purple-black stain in the outer sapwood of the lower bole and root system (images 4 & 5).

As the *Leptographium* fungus is not tolerant of high temperatures the staining is not usually found much above stump height. Several other non diagnostic symptoms that have been associated with BSRD could equally well be associated with other root diseases or drought. These symptoms include, crown chlorosis (image 3), premature needle loss and the development of distress crops of cones. Sometimes the disease can also reduce both needle length and internodal growth. Some of the dead and declining trees exhibited some of these (secondary) non-diagnostic symptoms.

Image 3. Douglas fir BSRD as a roadside disease and as disease of smaller trees. This roadside image was captured along a section of Highway 120 that is also captured in the aerial image (1). Notice there are no large dead trees along the edge of the road. Each year the California Department of Transportation fells all Hazard Trees along the road edge.

(4) (5).

Images 4 & 5. Basal symptoms of Douglas fir BSRD. Showing the chocolate brown to purple staining of the outer growth rings of sap wood. Isolations from the chips of wood in image 5 yielded the Douglas fir BSRD fungus. Notice the road in the background of image 4.

During the summer of 2008 FHP (before there had been an opportunity to have the stand aerially photographed) FHP was actively seeking an explanation for the Douglas fir decline in trees bordering Highway 120 and within the middle fork project area. Initial fungal isolations from the small roadside tree, shown in images 4 & 5, and a small tree on the edge of the landing shown in image1 produced *Leptographium wageneri*. While BSRD was suspected of being the cause of the mortality, all isolations from larger trees failed to yield this fungus.

Image 6. Galleries tentatively identified as belonging to the Douglas fir engraver.

Having difficulty in finding evidence of BSRD in many of the larger trees FHP turned its attention to looking for an insect cause for the mortality. Initial examinations of large dead trees revealed that they were heavily infested with a flat headed borer but there was little evidence of bark beetle activity. Initially the search was for either the Douglas fir bark beetle (*Dendroctonus pseudotsugae*) or the fir flat headed borer (*Phaenops drummondi*). When examining small trees from which *Leptographium* had been recovered the galleries of the Douglas fir engraver (*Scolytus unispinosus*) were discovered (image 6). The Douglas fir engraver is an insect that frequently attacks weakened or recently dead trees that have been stressed by root diseases or drought (Goheen & Willhite, 2006).

When slabs of bark from recently dead tree were placed in rearing chambers they yielded the Californian flat headed borer (*Phaenops californica*), and a, screened, long dead Douglas fir yielded (*Dicerca crassicollis*). Buprestid identifications were kindly made by Dr. Charles Bellamy of the CDFA diagnostic lab. Suspecting that it might be possible to capture the Douglas fir bark beetle (*Dendroctonus pseudotsugae*) and the fir flat headed borer, wet cup Lindgren

funnel traps were baited with a 1:1:1 mixture of lab ethanol (95%), turpentine (commercial paint thinner), and low-tox antifreeze were deployed in the summer of 2008. While these traps caught many insects they never caught a single fir flatheaded borer or a Douglas fir beetle. In the summer of 2009, Lindgrens baited with the Douglas fir beetle lure (Pherotech) replaced the homemade lure concoction. However, the commercial lure was no more effective in capturing a Douglas fir beetle, than had been the concoction used in 2008. It is possible that the D. fir beetle lure was deployed too late (in 2009) and that the beetles had already flown. Both SA files and local knowledge have never recorded the Douglas fir beetle being present in the Groveland RD.

On the late summer of 2008 forest health aerial reconnaissance of the Stanislaus National forest it was decided to fly over the Middle Fork project area and attempt to photograph "infection centers" observed along forest road 1S68. Unfortunately, these photographs contained no recognizable land marks that could be used for ground truth orientation. However landmarks in one image (image 1) which clearly included Highway 120 were locatable. Ranger district staff used Highway 120 and 3 other points of identification to locate the image on a forest map. This image is of a section of land immediately adjacent to the proposed thinning in the Middle fork project. As the pattern of mortality in image 1 is not consistent with a concept of radially expanding BSRD centers it was decided to survey the general area. As insects and diseases do not respect artificial man made boundaries; but move where ever the environment allows then to move it was decided to survey both the area in the image and the areas of the Middle Fork Project that have an apparent disease problem.

Survey Methods.

During the summer of 2009, ten tenth acre plots were distributed over the area covered in image 1, and another 10 plots were evenly distributed over that part of the adjacent middle fork project area that had forest road 1S68 running through it. Within each plot all stems greater than 5 inches were tallied. It quickly became apparent that the California Department of Transportation (Caltrans) has been in a habit of felling all dead trees that were once located within striking distance of Highway 120 (the access road from Groveland to Yosemite National Park). This observation necessitated dividing trees into 3 categories, standing living, standing dead, and felled dead. Breast Height Diameter (BDH) was recorded for all stems and when observed, the symptoms of characteristic of BSRD were recorded along with all signs and symptoms of insect or fungal attack. Each plot had its center marked with a redwood stake and its GPS coordinates were recorded. Each tree within the plots was tagged with an aluminum tree tag (affixed with an aluminum nail). As it is intended that these plots will be reassured periodically, maps were drawn up to aid in plot relocation and all data has been archived in FHP files.

Results and Observations.

Many of the characteristics that were tallied proved to shed little light on the situation. However, the mortality figures were highly informative. Twenty eight of the 29 dead trees in the two acres of plots were Douglas fir. The only other dead tree was a ponderosa pine. Of the dead Douglas fir on the two acres of plots only four had still attached needles. Basal resinosis and distress crops of cones were each observed only once and both were on Douglas fir trees. With the exception of one black oak tree that displayed both "D" shaped beetle exit holes and had red colored frass coming out of its bark all other insect and disease symptoms were restricted to

Douglas fir. With the exception of one dead ponderosa and the previously mentioned black oak all other pines and incense cedar trees were insect and fungal symptom free. As the mortality and diameter distributions (for Douglas fir) were the most informative data collected they have been presented in table 1 and figure 1.

	Basal Area		Trees on plots		spa	
	Living	Dead	Living	Dead	Living	Dead
Douglas fir	62.09	30.19	67	28	33.5	14
Ponderosa pine	30.47	0.26	17	1	8.5	0.5
Incense cedar	34.48		43		21.5	
Black oak	16.86		15		7.5	
Sugar pine	9.98		14		7	
Interior live oak	0.13		1		0.5	
Class total	154.01	30.45	157	29	78.5	14.5
Grand total	184.46		186		93	

Table 1. Survey data summary, with basal areas in sq ft/ acre. Total trees on plots is presented to avoid having to present data as partial trees per acre.

As can be seen in image 2 the dead Douglas fir trees have been dead for different lengths of time. In bark beetle mortality spots, the dead trees have usually all died within 1 or 2 years. In root rot centers trees can have been dying over decades and thus came from many classes. With the trees that have been dead the longest closest to the center of the mortality pocket. While image 1 did not reveal any circular root rot pockets, they were encountered in the general area of the image. It is possible that the slope of the ground, the height of the trees and the angle at which the photograph was taken all combined to obscure these pockets. In this survey no attempt was made to ascertain how long the dead trees had been dead. The observations support the hypothesis that most of the dead trees had been dead for 10 to 15 years. It is intended to periodically reassess these plots in order to obtain data on the rate of tree mortality.

The landing shown in image 2 was mistakenly taken as being evidence of a past thinning having been carried out in this area. There are no Ranger District records of there having been a thinning in the last decade or so. Local forest knowledge supports the idea that the last entry was at least 15 to 20 ago. The stump evidence encountered while establishing the plots supports the last entry having been well over 15 years ago. However, local knowledge and data bases do not rule out the possibility that there had been a roadside hazard tree salvage. Whorl counts of the ponderosa regeneration in the landing (image 2) gave an age of 8 - 10 years and a basal ring count of one of the larger trees gave an age of 11 years. It would have been safe to conclude that what ever the stand activity had been it occurred about 12 – 13 years ago. This might reasonably mean that all of the dead trees seen in the background of image 2 had all died in the last decade. There is evidence, in the vicinity of image 2, of firewood cutters having cut standing dead trees that the author remembers having had a yellow “H” painted on them. Caltrans fells dead trees along the highway and firewood cutters salvage dead trees along the edge of the forest roads.

This information was included to highlight the dangers of extrapolating from limited information and show how initially the role of BSRD may well have been overstated.

Although BSRD could not be isolated from the root collar area of largest dead trees in image 1, it was recovered from a Douglas fir pole at the margin of the landing. As this fungus can spread by root to root grafting it is possible that the root system of the large trees were colonized by the fungus and the trees died before the fungal stain had progressed to the region of root collar area. While establishing plots, several areas were encountered which had the appearance of having been root rot pockets. The vegetation of these pockets / centers had become dominated by deer brush (*Ceanothus integerrimus*). Yet other, individual dead Douglas firs were encountered that were not associated with a pocket or mortality center. *Phaeolus schweinitzii* conks were encountered growing on a large Douglas fir stump. *P. schweinitzii*, causes a root and but rot of Douglas fir that can produce large tree mortality. Thus in this area there was as much evidence for *P. schweinitzii* killing large trees as there was for BSRD. Never the less the role of BSRD in this decline can not be discounted. Like the buprestids, BSRD must be considered as contributing to tree mortality. .

Mortality as a percentage of the living stems.

6	12	18	24	30	34	40	46
0%	25%	43%	64%	50%	25%	0%	100%

Figure 1. Diameter class distribution for both the living and the dead Douglas fir. Additionally the dead trees in the graph have been expressed as a percentage of the living tree number for that diameter class

When flat headed borer adults emerge from trees they chew a "D" shaped exit hole. Sixty four percent of the dead Douglas fir trees had "D" shaped insect exit holes and four of them also had conks of the pouch fungus (*Cryptoporus volvatus*) on them. Despite an absence of significant bark beetle activity the pouch fungus was still present in the stand. As Harrington (1980) has pointed out the pouch fungus is not vectored by bark beetles, it simply makes use of insect exit holes to gain access to the sapwood of dead trees. In the absence of a bark beetle population the fungus survives by utilizing the exit holes of other insects, and in this case the exit holes of Buprestids were presumably used. Four living Douglas fir trees were observed bearing the conks of the white pocket rot fungus, *Phelinus pini*. As *P. pini* is a heart-rot fungus it is not surprising that it was not associated with the dead trees. To be associated with a decline disease the fungus would have to decay living tissue, *i.e*. living sapwood.

Discussion

During the 2008 aerial flight the author initially rated the areas mortality at no more than 2 trees per acre, and he was not aware of any previous sketch mapping history that would indicate that this level of mortality was anything other than the normal background mortality that is needed to accommodate in-growth as one diameter class grows into the next. In a retrospective article presented at an American Phytopathological Society sponsored symposium Professor Paul Manion introduced to the wider group of forest pathologist his contention that "forests need a healthy amount of disease." (Manion, 2003). In truth, Manion and Griffin (1998) had introduced the concept 5 years earlier, when addressing an International Congress of Pathology, in Edinburgh, Scotland. As insects and in particular bark beetles can (and do) kill trees as easily as pathogens, the Manion mantra should become "Forests need a healthy amount of death!" In light of the normal volume tables proposed for fully stocked stands Manion's "healthy amount of death" equates to the number of stems that are lost when the stand grows from one age class into the next age class. Returning to image 1 the question to be answered is; "Do those arrows on that image represent a healthy, normal, or background level of mortality?" From his airborne perch the author estimated the level of mortality at 1 - 2 stems per acre per year. Of the 29 dead trees in the 2 acres of plots only 4 had still had needles attached. If some of those trees had been dead for over a year this would equate to a mortality level of 1 - 2 stems per acre per year. If 1-2 stems are dying per year it would take 10-15 years to accumulate a number of dead trees equal to those tallied in this survey. As mentioned earlier, the periodic reassessment of these plots will provide data to confirm or refute this speculation.

At first assessment a mortality rate of 1 - 2 trees, per acre, per year might be an acceptable (healthy) level of background mortality. However, almost all of the mortality is clustered in one species. Douglas fir, which accounts for 40% of the living basal area, also accounts for 97% of the dead stems and 99% of the dead basal area. For every 2 square foot of living Douglas fir basal area there is 1 square foot of dead basal area. Clearly in this locality Douglas fir is in decline and the beneficiaries of this decline (in the short run) are the ponderosa pine and sugar pines, with the shade tolerant incense cedar likely to be the eventual victor. Incense cedar already has a commanding lead over the pines in number of stems and a slight lead over ponderosa pine in basal area. Death of the Douglas fir amounts to a biological thinning of the ponderosa and sugar pines. This is a thinning in which no pines have to die in order to provide the growing space necessary for the remaining pines, for all the "sacrifice" (mortality) is being made by the Douglas fir.

Figure 1 was constructed to describe where the Douglas fir mortality was occurring. In this survey the largest tree was a ponderosa pine at 44.9 inches. The second and third largest trees were both Douglas firs, one living and one dead! It can be seen from figure 1 that Douglas fir mortality is spread across all of the diameter classes. The average diameter of the dead Douglas firs is almost two inches greater than the average diameter of the living trees, 16.7 vs. 18.6 inches. In one of his more recent papers Professor Manion (2003) outlines his concepts of there being "a healthy amount of disease in a healthy forest." This amount of disease is what we would call the background mortality that occurs when a stand develops and trees in one diameter class grow into the next diameter class. Unfortunately the science of forest pathology has not progressed to the point where we can quantify what is a; "healthy amount of disease or death". However, the number of dead trees observed was expressed as a percentage of the diameter class to which they once belonged. This data is presented as an extra line in figure 1. When a normal tree volume table for fully stocked stand of a single species is compared for two successive age classes the diameter distribution from one decade to the next follows a pattern similar to that in figure 1.

The identification (by Dr Bellamy) that the buprestid reared from the recently dead trees was Californian flat headed borer (*Phaenops californica)* was unexpected, for this insect is best known for attacking pines. It was expected that the reared buprestid would have been fir flatheaded borer (*Phaenops drummondi*). Besides stating that in the insect usually attacks pines Lyon (1970) states "Most often the insects infests pines growing on shallow or rocky soils in stands at the fringe of forested areas where rainfall is light;" Much of the area of the Middle Fork Project area could easily be described as having a shallow rocky soil. Although the Middle fork area is not on the fringe of the forest it is on the fringe of where Douglas fir grows (at this elevation).

Attacks on Douglas fir by either the fir engraver or the California flatheaded borer are both made worse by droughts, and the soil of the project area is both shallow and rocky. The question arises, "Has the survey area been under a drought stress over the last 10 - 15 years?" Available rainfall data for the Groveland Ranger District only goes as far back as the 1997-1998 rainfall season. When the data trend for the Groveland, Mi-Wok and Summit Ranger Districts are compared the trend has been that, in 7 out of the last 10 years the rainfall totals have been below the long term average. There is not enough data available to ascertain if there has been a climate change in the Groveland RD. However, when Egan (2009) compared the deviation from the 30 year average for the NRCS SNOTEL station at Sonora Pass he found that 8 of the 10 years prior to 2008 had below average precipitation. Although the absolute amounts of precipitation for the 3 Ranger District Stations and the Sonora Pass location differ, they all follow the same trend: Lacking sufficient data all that can be said about the project area is that the trees have been under a water stress for much of the past decade. Of the species represented on the plots incense cedar is the most drought tolerant and Douglas fir is probably the least drought tolerant and thus it might be reasonable to expect some fir mortality. However, to have Douglas fir account for 97% of the mortality was not expected.

Ever since Robert Hartig adapted the germ theory to forest pathology (Merrill *et al*, 1975) forest pathologists have used the disease triangle (or adaptations of it) to explain mortality events involving one host species and one fungal pathogen. By the mid 60's pathologist were not able to fully explain tree decline by using the disease triangle. Pathologists frequently find that tree

deaths have many contributing factors. This led Sinclair (1965) to describe categories of factors to explain these multi-caused declines. A "Forest Decline Session" held at the 1988 American Phytopathological Society annual meeting was followed by a 1990 joint symposium between the American and Canadian Phytopathological Societies. Out of this joint "Forest Decline Symposium" came the APS publication "Forest Decline Concepts" edited by Manion and Lachance (1992)

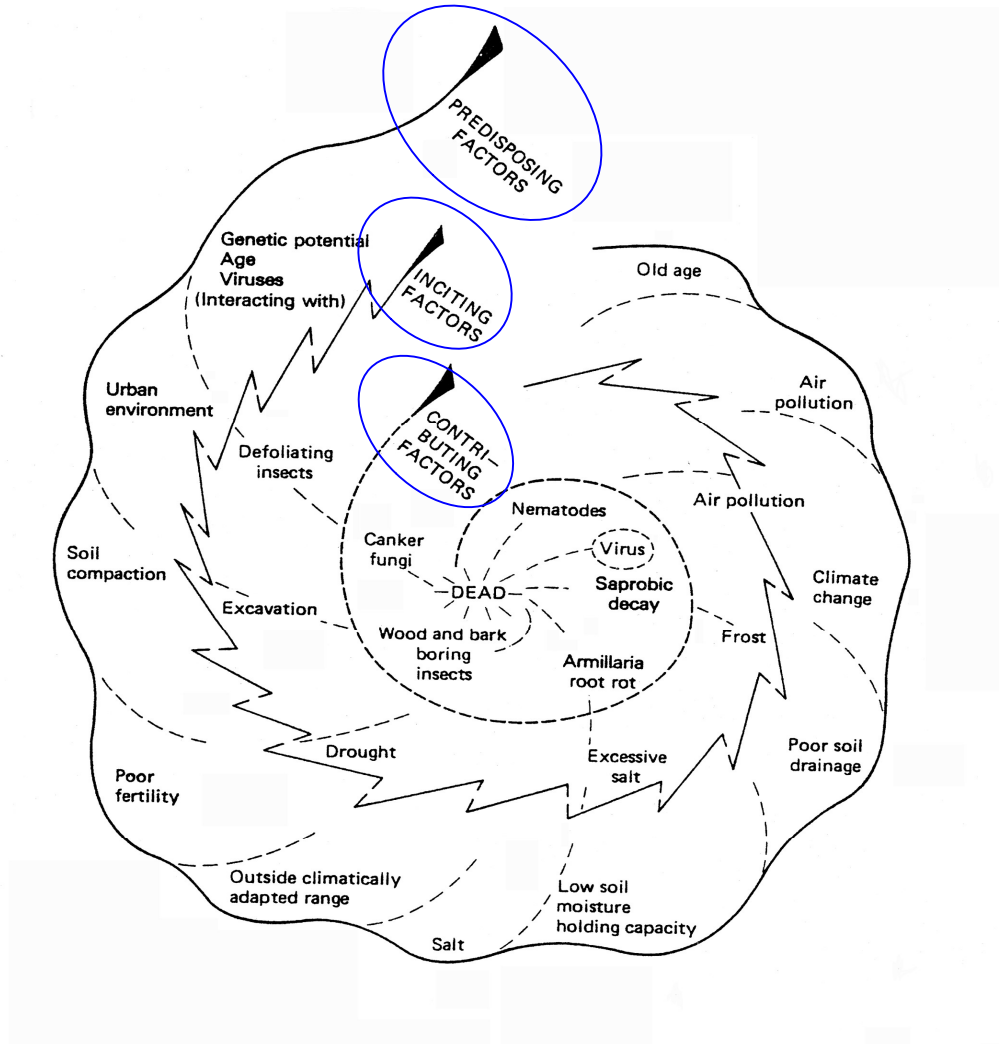

Figure 2. The Manion Decline Spiral, showing the 3 sets of stressors and most of the factors that could play a role in the complex that makes up an individual tree species decline.

In the first chapter of this publication Houston proposed "A Host-Stress-Saprogen model for Forest Dieback-decline Diseases". This model was essentially the disease triangle in three dimensions and became the disease tetrahedron. Houston had added time as another dimension to the triangle. Of all chapters in this book it was the last, "Forest Decline Concepts; an overview" by Manion and Lachance that has received the most attention. This chapter included the "Decline Disease Spiral" that had appeared a earlier in the textbook "Tree Disease Concepts", Manion (1991). The decline disease spiral, henceforth known as the Manion Spiral is presented as figure 2. . It was Sinclair (1965) who first divided stressors into 3 categories;

predisposing factors (i), **inciting factors** (ii) and, **contributing factors** (iii). The decline spiral predicts that a species can go into decline if one factor from each of the 3 groups is acting on a species at the same time. Initially a factor is needed to predispose the tree to a decline, then an inciting factor acts to trigger the decline and, finally a contributing will eventually kill the tree. While the model predicts that a tree can go into decline with only one factor from each of the 3 sets is acting upon the tree, in many documented decline examples there have been several factors from each of the sets acting upon the declining trees.

For the purposes of discussion the relevant stressors thought to be active on the on the Douglas fir in this corner of Stanislaus National Forest have been tabulated in table 2, below. Douglas fir growing above 5,000 ft, along the Clark Fork of the Stanislaus River appears to be as healthy as those growing at a similar elevation on the Sierra National Forest. The observed Douglas fir decline appears to be restricted to lower elevations of the Stanislaus National Forest.

(I) ***Predisposing factors***	***(II)*** ***Inciting factors***	***(III)*** ***Contributing factors***
Climate change	Drought	CA Flatheaded borer
Soil compaction	Cankers	BSRD
outside climatic range	defoliating insects	D. fir Engraver
dwarf mistletoe		other bark beetles
stand structure		etc.

Table 2. The stressors acting upon Douglas fir on the Groveland Ranger Districts of the Stanislaus National Forest tabulated in into the Sinclair Classes as used in the Manion Decline Spiral model, with the major stressors highlight in yellow.

Following the Manion model, the Climate Change and Soil compaction are viewed as being the predisposing factors, the drought is the inciting factor that triggered the mortality and the contributing factors that lead to tree death are viewed as being the insects and BSRD.

The best model to explain the Douglas fir decline observed here is the Manion Spiral. Using the Manion spiral we can suggest that under the current conditions at the lower elevational and altitudinal limits of Douglas fir on the Stanislaus National Forest the species is declining. The decline is probably driven by a recent and continued drought, and we can speculate that the decline might be evidence of a climate change.

Management Options for the declining Douglas fir stands.

A. No Active Management. Under a no action alternative there is every reason to believe that the Douglas fir will continue to decline and the site will progress towards becoming a pine type with a high content of incense cedar. Although the Douglas fir bark beetle and the fir flatheaded beetle have not yet been recovered from this area it is probable that one and possibly both insects

will build up in the next few years. Once in high enough population levels these insects will cause an increased level of mortality in fir that will be even more stressed than it is today.

B. Thinning to release the tensions of the Manion Spiral. The corollary to the Manion Decline Spiral is; that should one of the sets of factors be mitigated early enough then the spiral should unwind and the tree should recover. Mitigating the insects and fungi that negatively impact the Douglas fir is neither, desirable nor, particularly feasible. As changing climate or a local drought is impossible all we are left with is or ability to change stand conditions. The corollary to the Manion Decline Spiral (which is not often cited) is that should one of the sets of factors be mitigated early enough then the spiral should unwind and the tree should recover, provided an irreversible train of events has not already been initiated. Thinning is the best way to modify the stand conditions in the Middle Fork project area and "unwind" the Manion Spiral.

After reading the biology content of this report the Ranger District should do two things.

1. Consult its own stand data for more accurate figures.
2. Consult with the District and RO Silviculturists to translate Forest Health theory into a prescriptive form that marking crews can use.

The basic idea behind a Forest Health thinning, is to provide a reduced number of fir with a larger individual growing spaces. By providing more space for the residual fir the thinning will provide the individual trees with a greater volume of soil from which to absorb water. If as is speculated, water is the limiting factor, having fewer trees on the site will mean that individually each trees has access to a larger pool of water. Where firs are clustered they will need to be spaced out. In nature the competition for resources between trees of the same species is often more intense than the competition for resource when the species are different. The biggest threat to the health of a large Douglas fir is another large Douglas fir nearby; an incense cedar of a similar diameter might be less of a threat. Having spaced out the larger Douglas fir we want to retain, the second emphasis of a Forest Health thinning should be a move to remove the smaller diameter lower canopy tiers that are under the larger Douglas fir. This may occasionally mean removing smaller Douglas fir. However, the survey data indicates that 46% of the incense cedar stems are under 12 inches and 56% of the cedar stems are < 14 inches. It should be possible to create large growing spaces for the fir by removing smaller cedars. Although Black Oak is well represented in the stand and oak regeneration was plentiful, thinning oaks is not recommended for it can lead to an outbreak of Armillaria root rot in adjacent pines.

The easiest way to achieve a Forest Health Thinning would be to mark the stand under standard silvicultural guidelines, and then mark additional smaller trees whose crowns are close to the larger firs. It is recommended that these extra trees be removed from within the drip line and adjacent to the drip line of all Douglas fir trees 18 inches and larger. It is envisaged that all trees greater than 2 inches would be removed within the drip line of the Douglas firs > 18 inches. This brush cutting operation could be conducted after a regular thinning prescription has been carried out. Returning to Figure 1 it can be seen that the number of dead 18 inch trees tallied amounts to 43% of the living 18 inch diameter class. The percentage mortality jumps to 64% for the 24 inch

class. As stated earlier, the science of forest pathology is not advanced enough to be able to say definitively that this is an unhealthy amount of disease (mortality) in the diameter classes. Manion (2003) using a similar survey method to the one used here found the diameter class mortality in Adirondack sugar maple stands to be in order of 20-25%. Lacking better statistics it is the SA opinion that a Forest Health based thinning is needed to prevent further loss of Douglas fir from this corner of the Groveland Ranger District. When average rainfalls return closer to the longtime average the Douglas fir will recover.

It is the SA recommendation that the Ranger District consult their silviculturists to translate the Forest Biology presented here into a practicable thinning prescription.

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